FOUNDATION INVESTIGATION REPORT
PROPOSED RECONSTRUCTION OF
STRUCTURAL CULVERT - SITE 2-471-C
HIGHWAY 21 FROM KINCARDINE TO TIVERTON
G.W.P. 408-94-00
Agreement # 3005-E-0038

I.E.

Geocres No.: 41A-187

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Prepared for:

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Prepared by:

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PART A – FOUNDATION INVESTIGATION

1. INTRODUCTION

This report presents the results of a foundation investigation carried out in September 2006 by Infrastructure Engineering Group Inc. on behalf of SNC-Lavalin Engineers & Contractors Inc.

The assignment involves the reconstruction/rehabilitation of the pavement structure on Highway 21 from 0.63 m north of the intersection with Highway 9 (north of Kincardine) northerly to 1.2 km east of the intersection with Bruce County Road 15 (west junction in the Village of Tiverton) for 12.4 km; including pavement rehabilitation/reconstruction throughout, snow drifting/storage treatments, structural culvert replacement/rehabilitation, non-structural culvert replacement, minor intersection improvements, drainage improvements and minor electrical work.

Foundation investigation and recommendations are required for the design and construction of culvert replacements as part of the improvement of Highway 21. Five (5) structural culverts and twenty-four (24) non-structural culverts are to be investigated. This report covers the site of Structure 2-471-C.

The purpose of the investigation was to obtain information about the subsurface conditions at the site by means of boreholes and, based on the findings, to provide geotechnical recommendations for the foundation elements. The existing culvert is to be replaced with a new culvert.

Authorization to complete this assignment was given by Mr. Bing Wong, Project Manager, SNC-Lavalin Engineers and Constructors Inc., the TPM Consultant who is completing this assignment for MTO under Agreement # 3005-E-0038.

2. SITE DESCRIPTION

2.1 Site Location

Structure 2-471-C is located on Highway 21, approximately 2.4 km north of Highway 9, located at station 15+966. Photographs of this culvert site are presented in Appendix D. The existing structure is a reinforced concrete, rigid frame box culvert having dimensions of 3.60 m wide by 1.80 m high by 37.50 m long, with an overfill height of 4.85 m. The culvert opening dimensions were provided by AGM. A brown silty clay deposit was noted at the streambed.

The culvert site is located within a drainage valley in which the stream flows westward. The approach embankments were built on both the north and south sides of the culvert, with a maximum height of approximately 7 m. The embankment slopes are typically 2.5H to 3H:1V and are grass covered. No signs of embankment slope instability were observed at the time of this foundation investigation.

2.2 Physiography and Topography

The site is located within the Physiographic Region known as the "Huron–slope" (Chapman and Putnam, 1984) which occupies the area east of Lake Huron between Sarnia and Tobermory. The area is characterized by a flat topography, heavy textured soil and poor drainage. The surficial deposits consist of brown, calcareous clayey tills, which contain very few cobbles and boulders. The tills are known to be underlain by grey stratified clays of lacustrine origin.

The asphalt pavement surface over the existing culvert is near elevation 225.2 m while the ground surface at the base of the embankment and in the flood plain is between elevations 217 and 219 m.

3. INVESTIGATION PROCEDURES

3.1 Field Investigation

On September 6, 2006, a CME 55 drill rig was supplied by London Soil Test Limited and used on site for drilling and Standard Penetration Testing (SPT, following the procedures of ASTM D 1586). Three (3) boreholes were drilled and sampled to obtain data for foundation design of the proposed replacement culvert. The locations of the boreholes are shown on Drawing 1.

The boreholes were numbered 2-471-C-1 to 2-471-C-3 and the depths of sampling were as follows:

Borehole No.	Depth of Sampling (m)
2-471-C-1	8.08
2-471-C-2	8.08
2-471-C-3	14.17

Boreholes 2-471-C-1 and 2-471-C-2 were drilled using continuous flight solid stem augers and Borehole 2-471-C-3 was drilled using continuous flight hollow stem augers. Soil samples were retrieved at selected intervals throughout the depths of the boreholes in conjunction with Standard Penetration Tests (SPT). Samples were generally taken at intervals of depth of 0.75 m to the maximum depth of exploration.

Field pocket penetrometer was used on the retrieved SPT samples to determine the undrained shear strength of the cohesive soil deposits. It is noted that the measured shear strength value would be slightly lower than the actual value due to sampling disturbance.

Seepage and water levels were noted in each borehole during and at the completion of drilling and sampling. All boreholes were grouted with a bentonite/cement mix at completion of sampling in accordance with Ontario Regulation 903.

Our field engineer, Mr. Ralph Billings, P. Eng., supervised the fieldwork and worked under the direction of the project engineer, Mr. Eric Chung, P. Eng. Our field staff cleared the location of buried utilities and logged the boreholes. The soil samples obtained were placed in labeled containers and transported to IEG's London laboratory for further examination and laboratory testing.

The stations, offsets and ground surface elevations at the as drilled borehole locations were surveyed by AGM London and provided to Infrastructure Engineering Group Inc. for the purpose of this report.

The results of the drilling, sampling, in-situ testing and groundwater observations are summarized on the Record of Borehole sheets and enclosed in Appendix "A".

3.2 Laboratory Analysis

Geotechnical laboratory testing consisted of natural moisture content determinations and visual classifications of all retrieved soil samples. In addition, grain size analyses, Atterberg Limit tests and unit weight tests were performed on selected samples.

The results of the laboratory testing are presented on the Record of Borehole sheets (Appendix "A") and Laboratory Test Results (Figures 1 to 5, Appendix "B").

4. SUBSURFACE CONDITIONS

4.1 General Subsurface Conditions

Reference is made to the Record of Borehole sheets (Appendix "A") and Laboratory Test Results (Appendix "B") for detailed subsurface soil and groundwater conditions encountered in the boreholes. The stratigraphic boundaries shown on the Record of Borehole sheets are inferred from non-continuous sampling and, consequently, represent transitions between soil types rather than exact planes of geological change. The soil profiles depicting the subsurface conditions on Drawing 1 will vary between and beyond the borehole locations.

In general, the subsurface deposits at the site consist of loose to compact embankment fill placed on very stiff to hard silty clay till.

4.1.1 Pavement, Fill, Topsoil

Borehole 2-471-C-3, which was located at the west edge of existing pavement in the shoulder area, encountered 600 mm shoulder gravel. Underlying the shoulder gravel is the embankment fill material that extended to a depth of 7.16 m (elevation 217.95 m). The fill beneath the shoulder gravel typically consists of silty clay with organic inclusions.

At Boreholes 2-471-C-1 and 2-471-C-2, topsoil fill and sandy silt fill were contacted to depths of 1.68 m (elevation 217.50 m) and 0.90 m (elevation 217.65 m) respectively.

Five (5) grain size distributions of the embankment fill are shown on Figure 1 of Appendix “B”. Standard penetration tests yielded “N”-values from 6 to 19 blows per 0.3 m. The unit weight of the fill was measured to be in the range of 18.8 to 22.4 kN/m^3. This fill is generally brown in colour and the measured natural moisture contents range from 13 to 26%.

Two (2) silty clay fill samples were tested and exhibited the following Atterberg Limits. These results are shown in Figure 2 of Appendix “B” and summarized below:

Liquid Limit (W_L)	24 to 25%, average at 24.5%
Plastic Limit (W_P)	14%
Plasticity Index (I_p)	10 to 11%, average at 11.5%

Based on the above field and laboratory test results, together and tactile examination, the fill materials exhibited loose to compact compactness condition.

4.1.2 Silty Clay Till

A major stratum of brown to grey silty clay till was contacted below the embankment fill at Borehole 2-471-C-3 and the topsoil and sandy silt fill layers at Boreholes 2-471-C-1 and 2-471-C-2. Sandy silt to silt partings, seams and layers are present within the silty clay till. The silty clay till extended to the full depth of the boreholes as follows:

Borehole No.	Depth (m)	Elevation (m)
2-471-C-1	8.08	211.10
2-471-C-2	8.08	210.47
2-471-C-3	14.17	210.94

Twelve (12) grain size analyses were performed and the results are plotted on Figures 3 and 4 of Appendix “B”. Within the silty clay till, embedded sand and gravel particles were found, as well as wet silt partings and layers.

Standard penetration tests yielded "N"-values from 22 to over 100 blows per 0.3 m. Undrained shear strength as determined from field pocket penetrometer ranged from 150 to over 225 kPa that generally increased with increasing depths. The unit weight was measured to be between 22.3 and 23.4 kN/m^3.

Seven (7) samples were tested and exhibited the following Atterberg Limits. These results are shown in Figure 5 of Appendix "B" and summarized below:

Silty Clay Till (four samples)

Liquid Limit (W_L)	22 to 28%, average at 25.3%
Plastic Limit (W_P)	13 to 15%, average at 14.0%
Plasticity Index (I_p)	9 to 13%, average at 11.3%

Silt to Sandy Silt Layer within Silty Clay Till (three samples)

Liquid Limit (W_L)	14 to 15%, average at 14.3%
Plastic Limit (W_P)	12 to 13%, average at 12.7%
Plasticity Index (I_p)	1 to 2%, average at 1.7%

The natural moisture contents were in the range of 10 to 19%. These results are characteristic of clayey soils of low plasticity (CL) with sandy silt to silt (ML) partings, seams and layers. The measured natural moisture contents are generally near or below the measured plastic limits and indicate that the deposit is pre-consolidated.

Based on the above field and laboratory test results, together with visual and tactile examination, the silty clay till deposit exhibited very stiff to hard consistency.

4.2 Groundwater Conditions

The groundwater condition was monitored during and upon completion of sampling. On completion of drilling, groundwater level was noted in Borehole 2-471-C-2 at a depth of 4.6 m below ground surface, corresponding to elevation 213.95 m. The water entered the boreholes from the wet sandy silt to silt layers within the silty clay till stratum. The other two boreholes remained dry and open throughout the sampling operations.

The water level in the creek was less than 0.3m above the stream bed at the time of the investigation and reflected a low flow condition.

It should be noted that the groundwater level will fluctuate seasonally and in response to weather events. Under adverse conditions, water could be perched within the embankment fill and on top of the silty clay till. It is reasonable to assume that groundwater could be similar to the water level in the creek during high flow conditions.

5.0 STATEMENT OF LIMITATION

We recommend that once the details of the proposed structure are finalized, our recommendations should be reviewed for their specific applicability.

The Limitations of Report, as Quoted in Appendix "C", is an integral part of this report.

We trust that we have completed the assignment within the Terms of Reference for this project. If there are any questions concerning this report, please do not hesitate to contact our office.

Yours truly,
Infrastructure Engineering Group Inc.

Eric Y. Chung, M.Eng., P.Eng.
Designated MTO Contact

Joseph Law, P.Eng.
Project Manager

Tom O'Dwyer, P. Eng.
Quality Review Engineer

Drawing 1

Borehole Locations

And

Soil Strata

METRIC

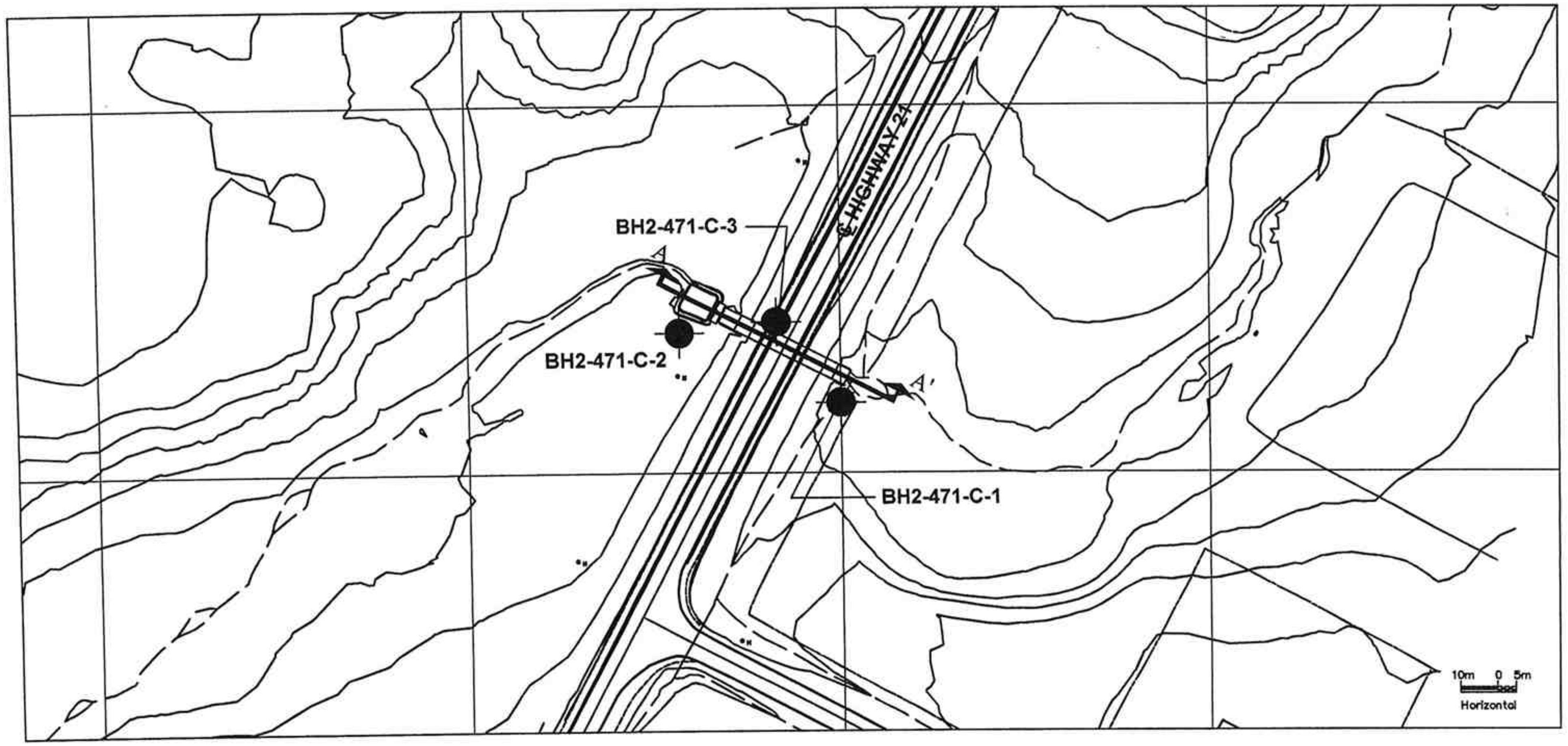
DIMENSIONS ARE IN METRES AND/OR MILLIMETRES UNLESS OTHERWISE SHOWN

CONT No xxxx–xxxx
WP No GWP 408–94–00

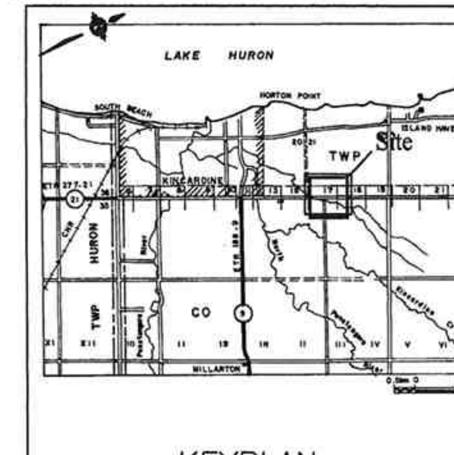
Culvert # 2–471
Highway 21
BORE HOLE LOCATIONS & SOIL STRATA

SHEET 1

I.E. Group — Infrastructure Engineering Group Inc.
Pavement & Construction Materials Consulting Engineers
GTA • Kitchener • London • Windsor



BOREHOLE LOCATION PLAN

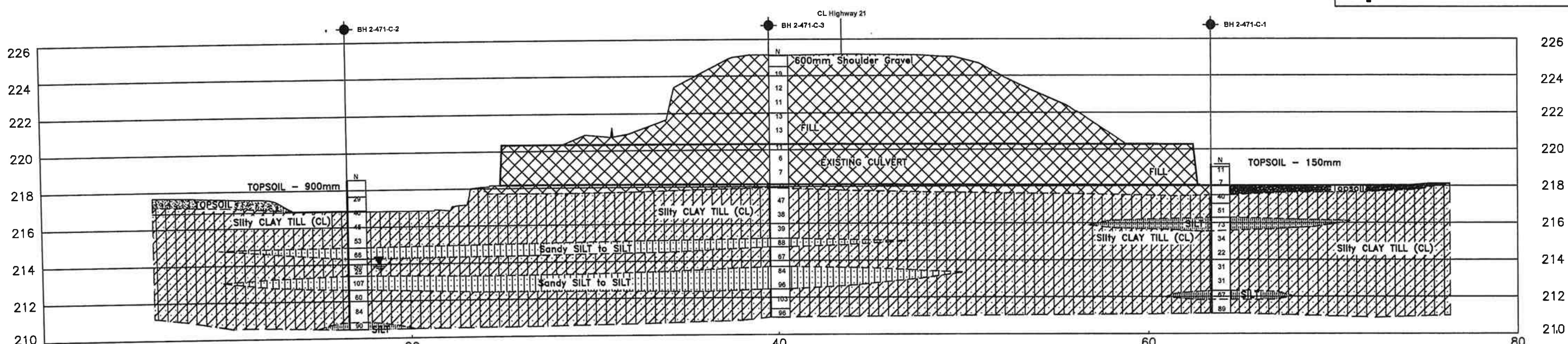


KEYPLAN

NTS

LEGEND

- Bore Hole
- Dynamic Cone Penetration Test (Cone)
- Bore Hole & Cone
- N — Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE — Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation
- Standpipe



SECTION A–A'
CENTERLINE OF CULVERT

REVISIONS		
28/09/07	J.L.	Final
17/01/07	J.L.	Draft
DATE	BY	DISCRIPTION

MTO GEOCRES No. 41A–187

BOREHOLE NO.	ELEVATION	UTM CO-ORDINATES NORTH	EAST
2–471–C–1	219.18	4895019	376600
2–471–C–2	218.55	4895038	376557
2–471–C–3	225.11	4895041	376583

HWY No.	HWY 21	DIST	Owen Sound
SUBM'D J.L.	CHECKED E.C. DATE 21/06/07	SITE	2–471–C
DRAWN J.L.	CHECKED J.L. APPROVED E.C.	DWG	1

NOTES

1. THE COMPLETE FOUNDATION INVESTIGATION AND DESIGN REPORT FOR THIS PROJECT AND OTHER RELATED DOCUMENTS MAY BE EXAMINED AT THE ENGINEERING MATERIALS OFFICE, DOWNSVIEW. INFORMATION CONTAINED IN THIS REPORT AND RELATED DOCUMENTS ARE SPECIFICALLY EXCLUDED IN ACCORDANCE WITH THE CONDITIONS OF SECTION GC2.01 of OPS GEN. COND.
2. THE BOUNDARIES BETWEEN SOIL STRATA HAVE BEEN ESTABLISHED ONLY AT BOREHOLE LOCATIONS. BETWEEN BOREHOLES AND BOUNDARIES ARE ASSUMED FROM GEOLOGICAL EVIDENCE.
3. THIS DRAWING IS FOR SUSURFACE INFORMATION ONLY. SURFACE DETAILS AND FEATURES ARE FOR CONCEPTUAL ILLUSTRATION.

Appendix A

Explanation of Terms Used in Report

Record of Borehole Sheet

Boreholes 2-471-C1 to 2-471-C3

EXPLANATION OF TERMS USED IN REPORT

N VALUE: THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS $\bar{N}$

DYNAMIC CONE PENETRATION TEST: CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

CONSISTENCY: COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH (c_u) AS FOLLOWS:

c_u (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	>200
	VERY SOFT	*SOFT*	*FIRM*	*STIFF*	*VERY STIFF*	*HARD*

DENSENESS: COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	>50
	VERY LOOSE	*LOOSE*	*COMPACT*	*DENSE*	*VERY DENSE*

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

RECOVERY: SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

MODIFIED RECOVERY: SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (R Q D), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	*POOR*	*FAIR*	*GOOD*	*EXCELLENT*

JOINTING AND BEDDING:

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	>3m
JOINTING	*VERY CLOSE*	*CLOSE*	*MOD. CLOSE*	*WIDE*	*VERY WIDE*
BEDDING	*VERY THIN*	*THIN*	*MEDIUM*	*THICK*	*VERY THICK*

ABBREVIATIONS AND SYMBOLS

FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

STRESS AND STRAIN

u_w	kPa	PORE WATER PRESSURE
r_u	1	PORE PRESSURE RATIO
σ	kPa	TOTAL NORMAL STRESS
σ'	kPa	EFFECTIVE NORMAL STRESS
τ	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
ϵ	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
μ	1	COEFFICIENT OF FRICTION

MECHANICAL PROPERTIES OF SOIL

m_v	kPa^{-1}	COEFFICIENT OF VOLUME CHANGE
C_c	1	COMPRESSION INDEX
C_s	1	SWELLING INDEX
C_α	1	RATE OF SECONDARY CONSOLIDATION
c_v	m^2/s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
T_v	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
σ'_{vo}	kPa	EFFECTIVE OVERBURDEN PRESSURE
σ'_p	kPa	PRECONSOLIDATION PRESSURE
τ_f	kPa	SHEAR STRENGTH
c'	kPa	EFFECTIVE COHESION INTERCEPT
ϕ'	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
c_u	kPa	APPARENT COHESION INTERCEPT
ϕ_u	-°	APPARENT ANGLE OF INTERNAL FRICTION
τ_R	kPa	RESIDUAL SHEAR STRENGTH
τ_r	kPa	REMOULDED SHEAR STRENGTH
S_t	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

PHYSICAL PROPERTIES OF SOIL

ρ_s	kg/m^3	DENSITY OF SOLID PARTICLES
γ_s	kN/m^3	UNIT WEIGHT OF SOLID PARTICLES
ρ_w	kg/m^3	DENSITY OF WATER
γ_w	kN/m^3	UNIT WEIGHT OF WATER
ρ	kg/m^3	DENSITY OF SOIL
γ	kN/m^3	UNIT WEIGHT OF SOIL
ρ_d	kg/m^3	DENSITY OF DRY SOIL
γ_d	kN/m^3	UNIT WEIGHT OF DRY SOIL
ρ_{sat}	kg/m^3	DENSITY OF SATURATED SOIL
γ_{sat}	kN/m^3	UNIT WEIGHT OF SATURATED SOIL
ρ'	kg/m^3	DENSITY OF SUBMERGED SOIL
γ'	kN/m^3	UNIT WEIGHT OF SUBMERGED SOIL

e	1, %	VOID RATIO
n	1, %	POROSITY
w	1, %	WATER CONTENT
S_r	%	DEGREE OF SATURATION
w_L	%	LIQUID LIMIT
w_P	%	PLASTIC LIMIT
w_s	%	SHRINKAGE LIMIT
I_P	%	PLASTICITY INDEX = $w_L - w_P$
I_L	1	LIQUIDITY INDEX = $\frac{w - w_P}{I_P}$
I_C		CONSISTENCY INDEX = $\frac{w_L - w}{I_P}$
e_{max}	1, %	VOID RATIO IN LOOSEST STATE

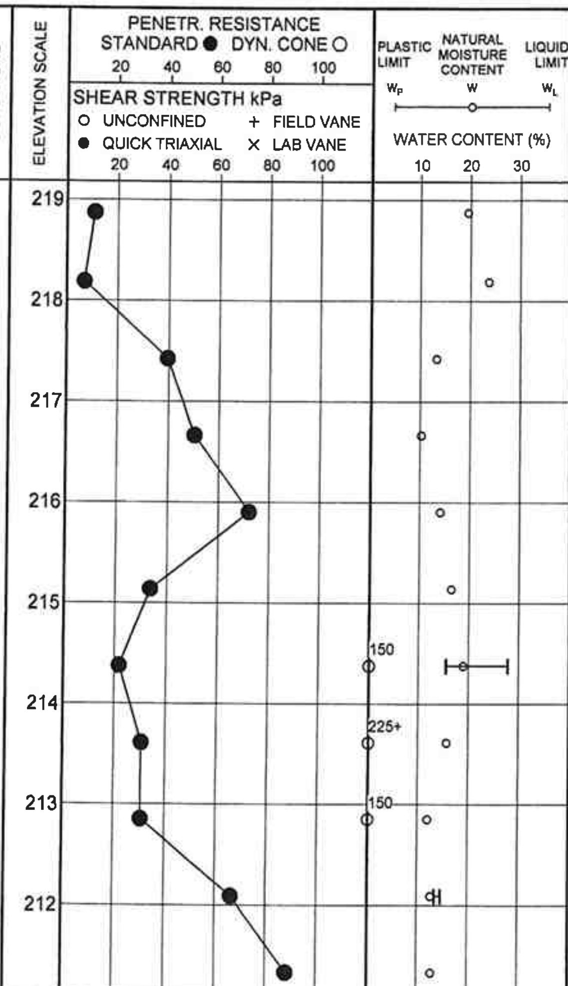
e_{min}	1, %	VOID RATIO IN DENSEST STATE
I_D	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
D	mm	GRAIN DIAMETER
D_n	mm	n PERCENT - DIAMETER
C_U	1	UNIFORMITY COEFFICIENT
h	m	HYDRAULIC HEAD OR POTENTIAL
q	m^3/s	RATE OF DISCHARGE
v	m/s	DISCHARGE VELOCITY
i	1	HYDRAULIC GRADIENT
k	m/s	HYDRAULIC CONDUCTIVITY
j	kN/m^3	SEEPAGE FORCE

RECORD OF BOREHOLE No 2-471-C-1

METRIC

W.P. GWP 408-94-00	LOCATION Site No. 2-471-C Northing - 4695019, Easting - 376600		ORIGINATED BY RB
DIST Owen Sound HWY 21	BOREHOLE TYPE 100mm SST Auger		COMPILED BY JL
DATUM Geodetic	DATE 09.06.06 - 09.06.06		CHECKED BY EC

ELEV / DEPTH	SOIL PROFILE – DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	UNIT WEIGHT γ kN/m³	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
219.18	Ground Surface						
0.00	TOPSOIL - 150mm	1	SS	11			
	FILL Brown, moist to wet, loose, consisting mainly of sandy silt.	2	SS	7		18.8	1 38 42 19 (62)
217.50 / 1.68	Silty CLAY TILL (CL) Grey, moist to wet, very stiff to hard, with embedded sand and gravel, interbedded with silt partings and seams, occasional silt layers.	3	SS	40			
	interbedded silt seams and partings	4	SS	51			0 7 71 22 (93)
	SILT layer	5	SS	73			1 7 80 11 (92)
		6	SS	34			
		7	SS	22		22.3	1 6 60 33 (93)
		8	SS	31			
		9	SS	31			
212.32 / 6.86	interbedded with wet silt seams and layers	10	SS	67			7 10 69 15 (83)
		11	SS	89			
211.10 / 8.08	End of Borehole						Borehole dry and open @ completion



$+^3, \times^3$: Numbers refer to Sensitivity

$○^{150}$ UNCONFINE SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No 2-471-C-2

METRIC

W.P. GWP 408-94-00 LOCATION Site No. 2-471-C Northing - 4895038, Easting - 376557 ORIGINATED BY RB
DIST Owen Sound HWY 21 BOREHOLE TYPE 100mm SST Auger COMPILED BY JL
DATUM Geodetic DATE 09.06.06 - 09.06.06 CHECKED BY EC

ELEV / DEPTH	DESCRIPTION	SAMPLE NUMBER	TYPE	"N" VALUES	GROUND WATER CONDITIONS	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
218.55	Ground Surface					
0.00	FILL - 900mm consisting mainly of topsoil	1	AUGER			
217.65 / 0.90	Brown Silty CLAY TILL (CL) Moist to wet, very stiff to hard, with embedded sand and gravel, sandy silt seams and layers.	2	SS	29		
		3	SS	40		3 9 59 29 (88)
		4	SS	45		
		5	SS	53		
	wet sandy silt layer	6	SS	66		6 23 58 14 (72)
	Grey	7	SS	50/25	∇	6 19 54 21 (75)
	wet sandy silt layers seams and partings	8	SS	107		1 23 59 17 (76)
		9	SS	60		
		10	SS	84		
210.47 / 8.08	sandy silt layer	11	SS	90		5 22 63 9 (73)
	End of Borehole.					Water level measured @ 4.6m @ completion.

Pocket penetrometer readings (unconfined shear strength, kPa): 225+ (sample 3), 175 (sample 4), 225+ (sample 5), 225+ (sample 7), 225+ (sample 9).

+ ³, × ³: Numbers refer to Sensitivity ○ ¹⁵⁰ UNCONFINE SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

RECORD OF BOREHOLE No 2-471-C-3

METRIC

W.P. GWP 408-94-00	LOCATION Site No. 2-471-C Northing - 4895041, Easting - 376583	ORIGINATED BY RB
DIST Owen Sound HWY 21	BOREHOLE TYPE 90mm HST Auger	COMPILED BY JL
DATUM Geodetic	DATE 09.06.06 - 09.06.06	CHECKED BY EC

SOIL PROFILE

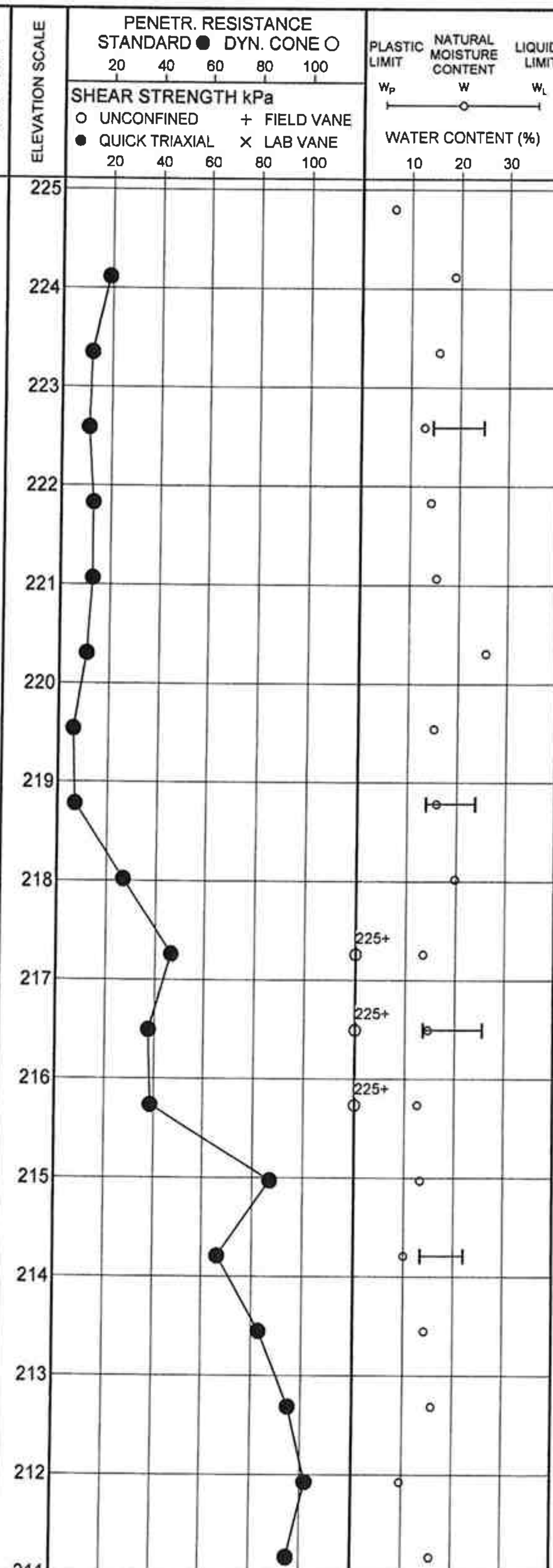
ELEV / DEPTH	DESCRIPTION
225.11	Ground Surface
0.00	FILL - 600mm, consisting of sand and gravel (shoulder gravel)
224.51 / 0.60	FILL Brown, damp, compact to loose, consisting of silty clay with organic inclusions
217.95 / 7.16	Brown Silty CLAY TILL (CL) Moist to wet, very stiff to hard, with embedded sand and gravel, frequent silt seams, pockets and layers Sandy Silt to Silt layers and seams Grey Sandy Silt to Silt layers and seams Sandy Silt to Silt layers and seams
210.94 / 14.17	End of Borehole

SAMPLES

NUMBER	TYPE	"N" VALUES	UNIT WEIGHT γ kN/m³	GR	SA	SI	CL
1	AUGER						
2	SS	19	21.9	1	14	57	28 (85)
3	SS	12					
4	SS	11		7	28	45	20 (65)
5	SS	13	21.9	2	13	57	28 (85)
6	SS	13					
7	SS	11					
8	SS	6					
9	SS	7	22.4	0	13	61	26 (86)
10	SS	27					
11	SS	47					
12	SS	38	23.4	0	6	61	33 (94)
13	SS	39					
14	SS	88		1	17	63	19 (82)
15	SS	67		0	8	66	26 (92)
16	SS	84					
17	SS	96					
18	SS	103					
19	SS	96					

GROUND WATER CONDITIONS

REMARKS & GRAIN SIZE DISTRIBUTION (%): Borehole dry and open at completion.



+[3], ×[3] Numbers refer to Sensitivity

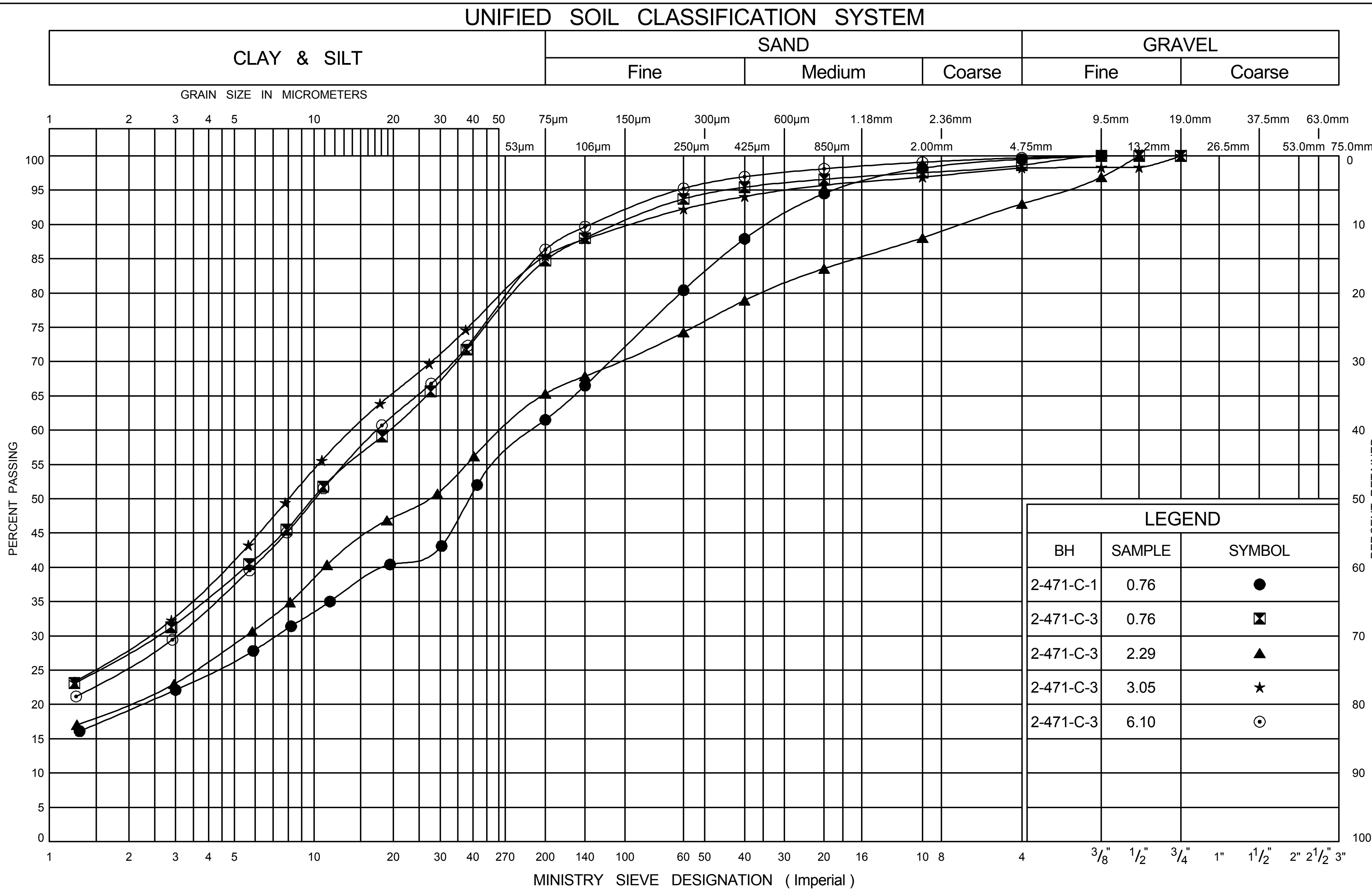
○[150] UNCONFINE SHEAR STRENGTH INFERRED FROM POCKET PENETROMETER READINGS

Appendix B

Laboratory Test Results

Grain Size Distribution	Figures 1, 3 and 4
Plasticity Chart	Figures 2 and 5

78 12 M



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GRAIN SIZE DISTRIBUTION

FILL

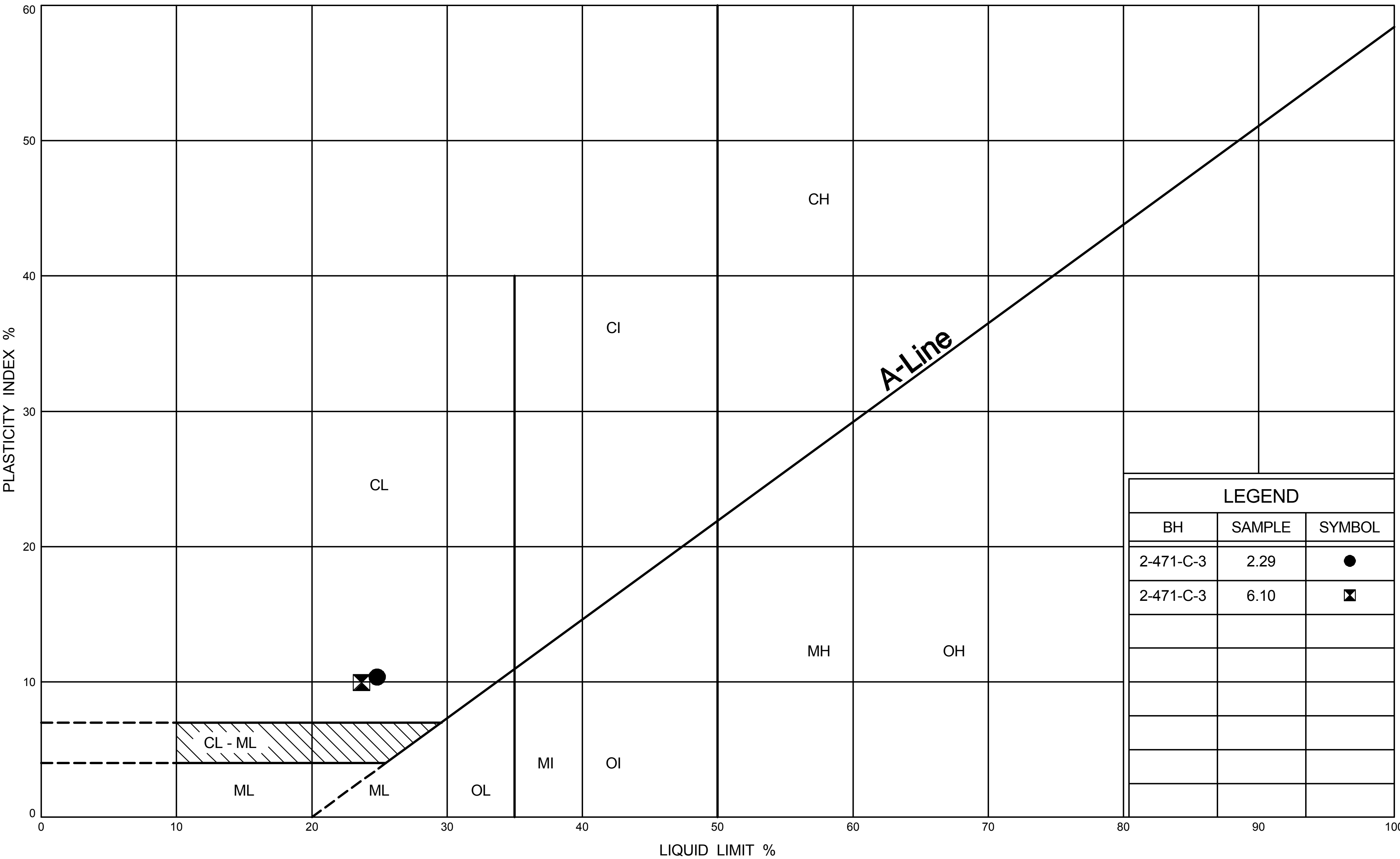
FIG No 1

GWP 408-94-00

Highway 21-Kincardine to Tiverton

ONTARIO MOT GRAIN SIZE LARGE CULVERTS 06-8-IEG2.GPJ ONTARIO MOT.GDT 6/22/07

Oct 75, FF - S - 21



LEGEND

BH	SAMPLE	SYMBOL
2-471-C-3	2.29	●
2-471-C-3	6.10	⧗

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PLASTICITY CHART

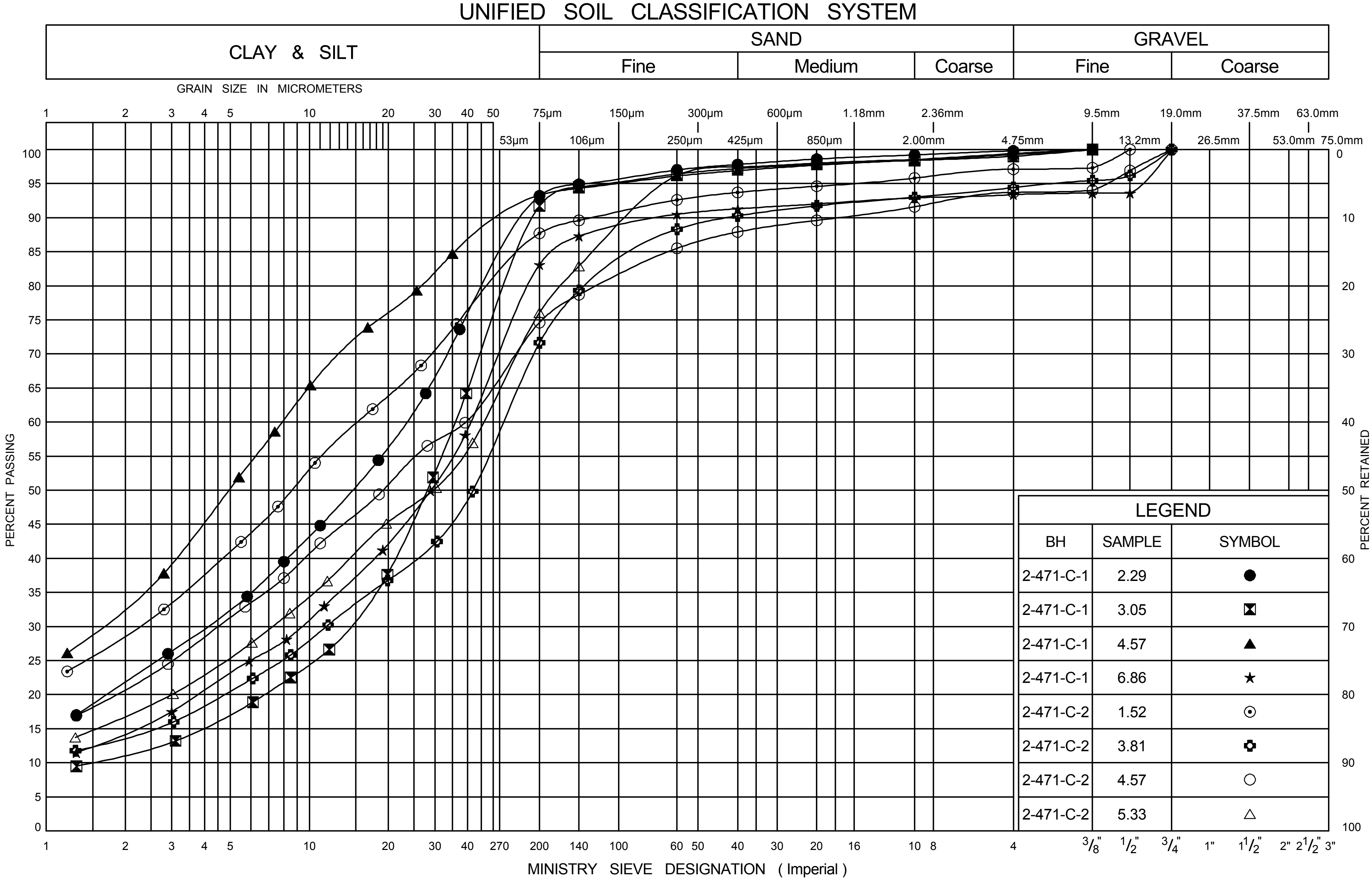
FILL

FIG No 2

GWP 408-94-00

Highway 21-Kincardine to Tiverton

78 12 M



LEGEND

BH	SAMPLE	SYMBOL
2-471-C-1	2.29	●
2-471-C-1	3.05	⊠
2-471-C-1	4.57	▲
2-471-C-1	6.86	★
2-471-C-2	1.52	⊙
2-471-C-2	3.81	✿
2-471-C-2	4.57	○
2-471-C-2	5.33	△

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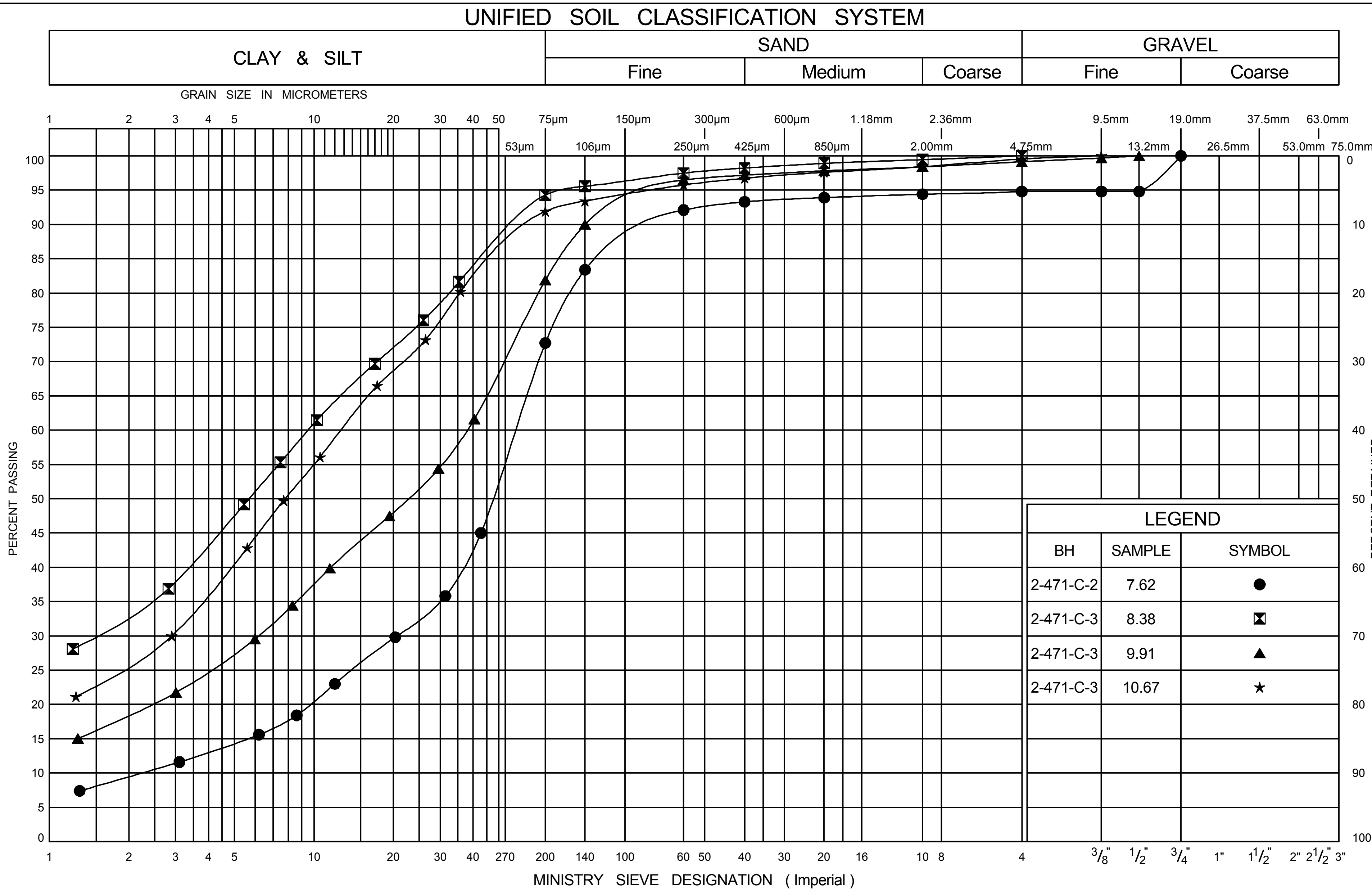
GRAIN SIZE DISTRIBUTION

SILTY CLAY TILL (CL)

FIG No 3

GWP 408-94-00

Highway 21-Kincardine to Tiverton



LEGEND		
BH	SAMPLE	SYMBOL
2-471-C-2	7.62	●
2-471-C-3	8.38	⊠
2-471-C-3	9.91	▲
2-471-C-3	10.67	★

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GRAIN SIZE DISTRIBUTION

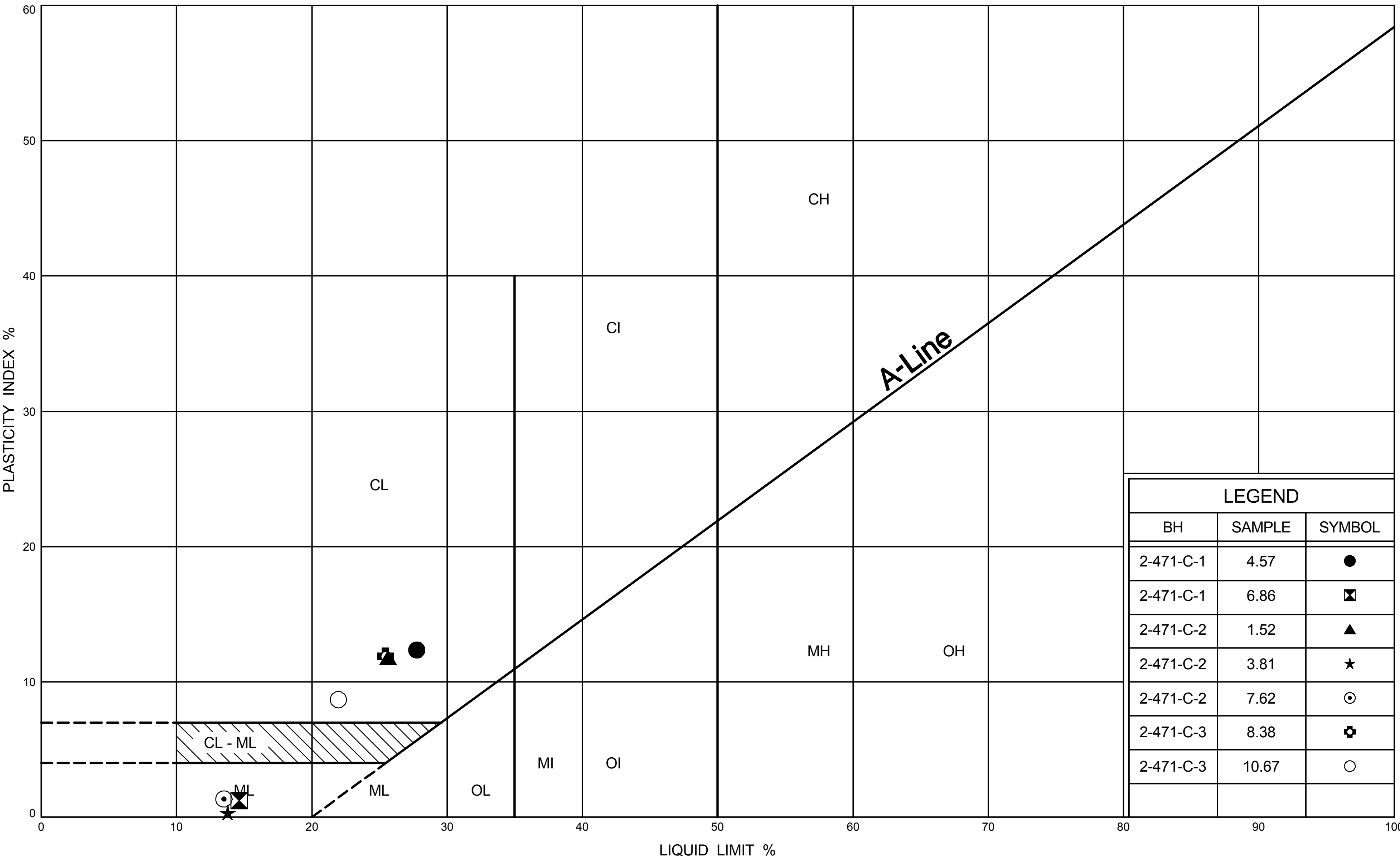
SILTY CLAY TILL (CL), with sandy silt to silt layers and seams

FIG No 4

GWP 408-94-00

Highway 21-Kincardine to Tiverton

Oct 75, FF - S - 21



LEGEND		
BH	SAMPLE	SYMBOL
2-471-C-1	4.57	●
2-471-C-1	6.86	⧗
2-471-C-2	1.52	▲
2-471-C-2	3.81	★
2-471-C-2	7.62	⊙
2-471-C-3	8.38	✪
2-471-C-3	10.67	○

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PLASTICITY CHART

SILTY CLAY TILL, with sandy silt to silt layers and seams

FIG No 5

GWP 408-94-00

Highway 21-Kincardine to Tiverton

ONTARIO MOT PLASTICITY CHART LARGE CULVE 06-8-IEG2.GPJ ONTARIO MOT.GDT 6/22/07

Appendix C

Limitations of Report

APPENDIX C

LIMITATIONS OF REPORT

The conclusions and recommendations given in this report are based on information determined at the testhole locations. Subsurface and groundwater conditions between and beyond the testholes may differ from those encountered at the testhole locations, and conditions may become apparent during construction which could not be detected or anticipated at the time of the site investigation. It is recommended practice that the Soils Engineer be retained during construction to confirm that the subsurface conditions throughout the site do not deviate materially from those encountered in the testholes.

The comments made in this report on potential construction problems and possible methods are intended only for the guidance of the designer. The number of testholes may not be sufficient to determine all the factors that may affect construction methods and costs. For example, the thickness of surficial topsoil or fill layers may vary markedly and unpredictably. The contractors bidding on this project or undertaking the construction should, therefore, make their own interpretation of the factual information presented and draw their own conclusion as to how the subsurface conditions may affect their work.

The benchmark and elevations mentioned in this report were obtained strictly for use in the geotechnical design of the project and by this office only, and should not be used by any other parties for any other purposes.

Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Infrastructure Engineering Group Inc. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

This report does not reflect the environmental issues or concerns unless otherwise stated in the report.

The design recommendations given in this report are applicable only to the project described in the text and then only if constructed substantially in accordance with the details stated in this report. Since all details of the design may not be known, IEG recommends that we be retained during the final design stage to verify that the design is consistent with our recommendations, and that assumptions made in our analysis are valid.

Appendix D

Site Photographs

Culvert #2-471-C - intlet side looking north

Culvert #2-471-C - intlet side looking east

Culvert #2-471-C - outlet side looking west

Culvert #2-471-C - outlet side looking north-east